

REMARKS

Claims 1-7, 9-23 and 25-27 remain in this application. Claims 1, 9, 10, 13, 14 23 and 27 have been amended and claims 8 and 24 cancelled.

Examiner Kin Chan Chen is thanked for having thoroughly examined the present invention.

Following the suggestion of the examiner, the acronym (CMP), though defined, has been deleted from claims 10, 13, 24 and 27. The applicant would like to thank the examiner for having pointed out a typographical error in claim 13, line 1. That error has been corrected to read "The method of claim 14, wherein" It is believed that with these corrections, claim objections have been overcome, and it is so requested, respectfully.

Reconsideration of the rejection of claims 9 and 23 under 35 USC 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention, is

respectfully requested in view of the amendments and for the reasons given below.

The phrase "such as" has been deleted from claims 9 and 23. So have the trade marks SiLK and FLARE. It is believed that claim 9 and 23 are now allowable, and it is so requested, respectfully.

Reconsideration of the rejection of claims 1, 2, 4, 5, 7, 10, 11, and 13 under 35 USC 102(b) as anticipated by or, in the alternative, under 35 USC 103(a) as obvious over Lin, et al., (U.S. 6,042,999), is respectfully requested in view of the amendments and for the reasons given below.

Claim 1 has been amended to distinguish the present invention from the reference. The limitation cited in claim 8 has been incorporated into claim one, and accordingly, claim 8 has been cancelled. That is, claim 1 now cites the fill material comprising I-line photo resist, which the cited reference lacks. Claim 1 has been further amended to cite the removal of the excess fill material by chemical mechanical polishing, which, again, is totally lacking in the cited reference. For, neither does Lin use I-line photo resist as a fill material, nor does he/she use

chemical mechanical polishing to remove his BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant goes to great lengths in disclosing that conventional etching processes introduce moisture into insulative layers (page 18, lines 1-3), giving rise to voids, cavities for contaminants to enter, poor interfaces between contacting conductors, and hence, poor connections between interconnects. It is also disclosed that low-k materials are susceptible to form interactions with photore-sist materials, and hence etching can leave behind photore-sist residue, which are detrimental in forming poisoned contact/via holes (page 18, lines 13-20).

As further stated starting on line 15 on page 19 of the instant specification:

It is a main feature and key aspect of the present invention, therefore, to fill the hole opening with a material that will not only protect the via

from poisoning, but also from volcano effect. It is disclosed hereby that the proper fill material is a specific photoresist, namely, I-line photoresist (line-line PR), or, a spin-on organic oxide such as SiLK and FLARE. An added advantage of using the line-line photoresist is that it is more suitable, in comparison with DUV-PR, for higher wavelength radiation that is needed for patterning deep submicron features of today's ULSI technology.

The applicant further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using wet etching.

In view of the amendments and the reasons given above, it is believed that base claim 1 is now clearly distinguishable from the cited reference, and therefore, allowable, and hence also claims 2, 4, 5, 7, 10, 11, and 13 dependent from claim 1, and it is so requested, respectfully.

Reconsideration of the rejection of claim 12 under 35 USC 103(a) as being unpatentable over Lin, et al., (US

Patent 6,042,999) is respectfully requested in view of the amendments and for the reasons given below.

Claim 1 has been amended to distinguish the present invention from the reference. The limitation cited in claim 8 has been incorporated into claim one, and accordingly, claim 8 has been cancelled. That is, claim 1 now cites the fill material comprising I-line photo resist, which the cited reference lacks. Claim 1 has been further amended to cite the removal of the excess fill material by chemical mechanical polishing, which, again, is totally lacking in the cited reference. For, neither does Lin use I-line photo resist as a fill material, nor does he/she use chemical mechanical polishing to remove his BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant, on the other hand, further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using wet etching.

In view of the amendments and the reasons given above, it is believed that base claim 1 is now clearly distinguishable from the cited reference, and therefore, allowable, and hence also claim 12 dependent from claim 1, and it is so requested, respectfully.

Reconsideration of the rejection of claims 3 and 6 under 35 USC 103(a) as being unpatentable over Lin, et al., (US Patent 6,042,999) as applied to claim 1 above, and further in view of Tsai, et al., (US Patent 6,326,296 B1), is respectfully requested in view of the amendments and for the reasons given below.

Claim 1 has been amended to distinguish the present invention from the reference. The limitation cited in claim 8 has been incorporated into claim one, and accordingly, claim 8 has been cancelled. That is, claim 1 now cites the fill material comprising I-line photo resist, which the cited reference lacks. Claim 1 has been further amended to cite the removal of the excess fill material by chemical mechanical polishing, which, again, is totally lacking in the cited reference. For, neither does Lin use I-line photo resist as a fill material, nor does he/she use

chemical mechanical polishing to remove his BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant, on the other hand, further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using wet etching.

In view of the amendments and the reasons given above, it is believed that base claim 1 is now clearly distinguishable from the cited references, and therefore, allowable, and hence also claims 3 and 6 dependent from claim 1, and it is so requested, respectfully.

Reconsideration of the rejection of claims 8 and 9 under 35 USC 103(a) as being unpatentable over Lin, et al., (US Patent 6,042,999) as applied to claim 1 above, and further in view of Wang, et al., (US 6,057,239), is respectfully requested in view of the amendments and for the reasons given below.

Claim 1 has been amended to distinguish the present invention from the reference. The limitation cited in claim 8 has been incorporated into claim one, and accordingly, claim 8 has been cancelled. That is, claim 1 now cites the fill material comprising I-line photo resist, which the cited reference lacks. Claim 1 has been further amended to cite the removal of the excess fill material by chemical mechanical polishing, which, again, is totally lacking in the cited reference. For, neither does Lin use I-line photo resist as a fill material, nor does he/she use chemical mechanical polishing to remove his BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant, on the other hand, further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using wet etching.

In view of the amendments and the reasons given above, it is believed that base claim 1 is now clearly distinguishable from the cited reference, and therefore, allowable, and hence also claims 8 and 9 dependent from claim 1, and it is so requested, respectfully.

Reconsideration of the rejection of claims 14-16, 18, 19, 21, and 24-27 under 35 USC 103(a) as being unpatentable over Lin, et al., (US Patent 6,042,999) in view of admitted art, is respectfully requested in view of the amendments and for the reasons given below.

Claim 14 has been amended to distinguish the present invention from the reference. The limitation cited in claim 24 has been incorporated into claim one, and accordingly, claim 24 has been cancelled. That is, claim 14 now cites the fill material comprising I-line photo resist, which the cited reference lacks. Claim 14 has been further amended to cite the removal of the excess fill material by chemical mechanical polishing, which, again, is totally lacking in the cited reference. For, neither does Lin use I-line photo resist as a fill material, nor does he/she use chemical mechanical polishing to remove his BARC layer. Lin specifically discloses that he/she uses a timed-removal

with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant goes to great lengths in disclosing that conventional etching processes introduce moisture into insulative layers (page 18, lines 1-3), giving rise to voids, cavities for contaminants to enter, poor interfaces between contacting conductors, and hence, poor connections between interconnects. It is also disclosed that low-k materials are susceptible to form interactions with photore-sist materials, and hence etching can leave behind photore-sist residue, which are detrimental in forming poisoned contact/via holes (page 18, lines 13-20).

As further stated starting on line 15 on page 19 of the instant specification:

It is a main feature and key aspect of the present invention, therefore, to fill the hole opening with a material that will not only protect the via from poisoning, but also from volcano effect. It is disclosed hereby that the proper fill material is a

specific photoresist, namely, I-line photoresist (I-line PR), or, a spin-on organic oxide such as SiLK and FLARE. An added advantage of using the I-line photoresist is that it is more suitable, in comparison with DUV-PR, for higher wavelength radiation that is needed for patterning deep submicron features of today's ULSI technology.

The applicant further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using wet etching.

In view of the amendments and the reasons given above, it is believed that base claim 14 is now clearly distinguishable from the cited reference, and therefore, allowable, and hence also claims 15, 16, 18, 19, 21, and 25, 26 and 27 dependent from claim 14, and it is so requested, respectfully.

Reconsideration of the rejection of claims 17 and 20 under 35 USC 103(a) as being unpatentable over Lin, et al., (US Patent 6,042,999) and admitted prior art as applied to claim 14 above, and further in view of Tsai, et al., (US

Patent 6,326,296 B1), is respectfully requested in view of the amendments and for the reasons given below.

Claim 14 has been amended to distinguish the present invention from the reference. The limitation cited in claim 24 has been incorporated into claim one, and accordingly, claim 24 has been cancelled. That is, claim 14 now cites the fill material comprising I-line photo resist, which the cited reference lacks. Claim 14 has been further amended to cite the removal of the excess fill material by chemical mechanical polishing, which, again, is totally lacking in the cited reference. For, neither does Lin use I-line photo resist as a fill material, nor does he/she use chemical mechanical polishing to remove his BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant, on the other hand, further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using wet etching.

In view of the amendments and the reasons given above, it is believed that base claim 14 is now clearly distinguishable from the cited reference, and therefore, allowable, and hence also claims 17 and 20 dependent from claim 14, and it is so requested, respectfully.

Reconsideration of the rejection of claims 22 and 23 under 35 USC 103(a) as being unpatentable over Lin, et al., (US Patent 6,042,999) and admitted prior art as applied to claim 14 above, and further in view of Wang, et al., (US Patent 6,057,239), is respectfully requested in view of the amendments and for the reasons given below.

Claim 14 has been amended to distinguish the present invention from the reference. The limitation cited in claim 24 has been incorporated into claim one, and accordingly, claim 24 has been cancelled. That is, claim 14 now cites the fill material comprising I-line photo resist, which the cited reference lacks. Claim 14 has been further amended to cite the removal of the excess fill material by chemical mechanical polishing, which, again, is totally lacking in the cited reference. For, neither does Lin use I-line photo resist as a fill material, nor does he/she use

chemical mechanical polishing to remove his BARC layer. Lin specifically discloses that he/she uses a timed-removal with a recipe comprising O_2/N_2 for a period between about 30 to 60 seconds (column 7, lines 5-6. Also, see claim 1, column 8, line 1, claim 22, column 9, lines 50-51 and claim 38, column 10, line 46).

The applicant, on the other hand, further discloses that the excess filling material is removed by chemical mechanical polishing to avoid any moisture that may enter into the hole when using wet etching.

In view of the amendments and the reasons given above, it is believed that base claim 14 is now clearly distinguishable from the cited reference, and therefore, allowable, and hence also claims 22 and 23 dependent from claim 14, and it is so requested, respectfully.

It is respectfully suggested that the combination of these various references cannot be combined without reference to applicant's own invention. None of the applied references address the problem of via poisoning or volcano effect. Applicant has claimed his process in detail. The processes of Figs. 2a-2i (Claims 1-27 as amended) are be-

lieved to be novel and patentable over these various references, because there is not sufficient basis for concluding that the combination of claimed elements would have been obvious to one skilled in the art. That is to say, there must be something in the prior art or line of reasoning to suggest that the combination of these various references is desirable. The use of an I-line photoresist and removal of the same using chemical mechanical polishing is not contemplated by any one of the cited references. We believe that there is no such basis for the combination. We therefore request respectfully that examiner Kin Chan Chen reconsider this rejection in view of these arguments and the amendments to the claims, and allow claims 1-27 as amended.

Allowance of all claims, as amended, is requested.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned **"Version with Marking to Show Changes Made."**

It is requested that should the Examiner not find that the Claims Allowable that are now presented, that

he/she call the undersigned Attorney at 845/452-5863 to overcome any problems preventing allowance.

Respectfully submitted,

A handwritten signature in black ink, appearing to be 'SBA', with a long horizontal flourish extending to the right.

Stephen B. Ackerman, Reg. No: 37,761

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS

The following claims have been amended as follows:

1. A method of eliminating volcano effect in dual damascene comprising the steps of:
 - 3 providing a substrate having first and second insulative layers, optionally separated from each other by an inter-
6 vening etch-stop layer formed thereon said substrate;

forming a hole opening through said first and second insu-
9 lative layers;

forming a fill material over said substrate, including in
12 said hole opening, wherein said fill material comprises I-
line photo resist;

15 removing any excess fill material over said hole opening,
wherein said removing said any excess fill material is ac-
complished by chemical mechanical polishing;

18

forming a trench opening in said second insulative layer over said hole opening in said first insulative layer, thus
21 completing the forming of said dual damascene structure on said substrate;

24 removing said fill material from said hole opening;

depositing metal in said dual damascene structure; and

27

removing excess metal to complete the forming of said dual damascene without the volcano effect.

30

Claim 8 has been cancelled.

9. The method according to claim 1, wherein said fill material comprises spin-on organic oxide [such as SiLK or
3 FLARE].

10. The method according to claim 1, wherein said removing said [excess] fill material is accomplished by [chemical
3 mechanical polishing (CMP), or] etching.

13. The method according to claim 1, wherein said removing
said excess metal is accomplished by chemical mechanical
3 polishing [(CMP)].

14. A method of eliminating volcano effect in dual damascene
comprising the steps of:

3

providing a substrate having a passivation layer formed
over a first metal layer formed on said substrate;

6

forming a first insulative layer over said substrate;

9 forming an optional etch-stop layer over said first insula-
tive layer;

12 forming a second insulative layer over said etch-stop
layer;

15 forming a first photoresist layer over said second insula-
tive layer and patterning said photoresist to form a first
photoresist mask having a hole pattern;

18

etching said first and second insulative layers, including
said optional etch-stop layer through said hole pattern to
21 form a hole reaching said passivation layer;

removing said first photoresist mask;

24 forming a fill material over said substrate, including in
said hole opening wherein said fill material comprises I-
27 line photo resist;

removing any excess fill material over said hole opening,
30 wherein said removing is accomplished by chemical mechani-
cal polishing;

33 forming a second photoresist layer over said substrate, in-
cluding said hole opening and patterning said second photo-
resist to form a second photoresist mask having a trench
36 pattern;

etching said second insulative layer through said trench
39 pattern in said second photoresist mask to form a trench in
said second insulative layer, thus completing the forming
of said dual damascene structure in said substrate ;

42

removing said second photoresist mask;

45 removing said fill material from said hole opening;

depositing a second metal in said dual damascene structure;

48 and

removing excess metal to complete the forming of said dual
51 damascene without the volcano effect.

23. The method according to claim [1] 14, wherein said fill
material is spin-on organic oxide [,such as SiLK or FLARE].

3

Claim 24 has been cancelled.

27. The method according to claim 14, wherein said removing
said excess metal is accomplished by chemical mechanical
3 polishing [(CMP)].